ABSTRACTS (MASTER THESIS)

Development of carbonized cellulose as catalytic cathode in fuel cells

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Introduction

Research and development of environment-friendly energy is conducted worldwide. Fuel cells are significantly more energy efficient and cleaner than combustion-based power generation technology. Especially, polymer electrolyte fuel cells (PEFC) have attracted much attention in recent years as platinum applied as a catalytic electrode in PEFC is an extremely expensive precious metal. Therefore, the development of low-cost non-platinum catalyst is needed. One of the solutions is to use nitrogen-doped carbon as cathode material, which has been recognized as a promising root to enhance the electrocatalytic activity of carbon materials. Cellulose, from a renewable biomass resource, was used as a raw material in this study. Cellulose acetoacetate (CAA) was prepared in order to introduce metal ions such as Fe or Co into cellulose. In this study, cellulose acetoacetate prepared from microcrystalline cellulose was at first metal (Co,Fe) loaded then N-doped with melamine and the effects of the chemical and carbonization treatments on the chemical composition, microtexture and electrochemical performance of the materials were investigated.

Materials and Methods

Metal loaded CAA, prepared with diketene, mixed with melamine as nitrogen source was carbonized at 600-900ºC under N2 atmosphere by applying a pulse current sintering method, in which current is directed straight through the graphite dies as well as the sample, so that the sample was heated both from the inside and outside at the same time. This method can be considered to control pore size distribution by changing the heating rate which depends on the current applied to the sample. Surface chemistry of N-doped carbonized cellulose was investigated using X-ray photoelectron spectroscopy (XPS). The microstructure of the carbons was characterized by transmission electron microscopy (TEM) and N2 adsorption measurement. The ORR activity of the N-doped carbonized CAA particles was studied using the rotating disk electrode voltammetry.

Results and Discussion

BET specific surface area measurements on the sample with Co carbonized at 800°C resulted in 200m2/g and a shell-like nanostructure. The potential which was measured at the current density of -2μAcm-2 in the electrochemical measurement for N-doped carbons showed a clear dependence on sintering temperature. Graphitic nitrogen measured with XPS seemed to contribute to the improvement of the potential. Crystallization and the reaction of carbon with nitrogen seemed to have an important influence.

Conclusion

The present study shows that the catalytic action of transition metals during carbonization of CAA performed by pulse current sintering at different temperature and the nitrogen doping modify both the microtexture and the chemical composition of the carbonized material and consequently control the oxygen reduction reaction activity.

References

Asakura, R., T. Hata, Y. Uchimoto, R. Benoit, S. Bonnamy, P. Bronsveld, T. Yoshimura, "Carbonized cellulose as catalytic cathode in fuel cells," Proceedings of 1st International Symposium for Sustainable Humanosphere (ISSH2011), pp.55-52, 2011.